EFFECT OF MOISTURE CONTENT ON COLLAPSIBILITY RATE AT GAMBANG RESIDUAL SOIL

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ABSTRACT

Residual soil is a material formed in situ by weathering of rock and remained at the place where it was formed. In Malaysia, residual soil covers more than 80% of the country land area. This type of soil has high possibility to collapse when raining or wetted. The objectives of this study are to determine the collapsibility rate of soil at Gambang and to determine the factors that cause collapsibility and the effect of wet soil on the collapsibility. Gambang has been choose as the case study because of the topography of the land is hilly and this place has a history of land slide, there is also a slop that is not covered by plan and it seems that the slope crack during the sunny day and if the rain comes, the soil will wetted and collapse. One-Dimensional consolidation test or oedometer test is carried out to test the soil sample. From the result obtained, the soil is found with collapse possibility because of the quantity of the void ratio is high and the soil has low shear strength. The soil collapsibility rate is found high after the test has been conducted.

ABSTRAK

Tanah baki adalah satu bahan dibentuk di suatu tempat oleh proses luluhawa batuan dan kekal pada tempat ia di bentuk. Di Malaysia, tanah baki meliputi lebih daripada 80% kawasan di negara ini. Jenis tanah ini mempunyai kemungkinan besar untuk roboh semasa hujan atau basah. Objektif-objektif bagi kajian ini adalah menentukan kadar tanah runtuh bagi tanah di Gambang, menentukan faktor yang menyebabkan tanah runtuh dan kesan kelembapan pada tanah runtuh. Gambang telah dipilih sebagai kes kejadian kerana topografi bagi tanah adalah berbukit dan tempat ini mempunyai sejarah berlakunya tanah runtuh, terdapat juga curam-curam yang tidak dilutupi tumbahan dan tanah merekah apabila cuaca panas, jika hujan turun pada keaadan tanah yang kering, kemungkinan tanah itu akan runtuh. Ujian pengukuhan 1 dimensi dijalankan untuk menguji sampel tanah. Daripada hasil kajian, didapati bahawa tanah di gambang akan runtuh, ini kerana kuantiti nisbah lowong adalah tinggi dan kekuatan ricih tanah adalah rendah. Kadar keruntuhan tanah adalah tinggi selepas kajian dijalankan.

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LIST OF SYMBOLS

i	-	Collapse potential	e_f	-	Final void ratio
h_i	-	Initial height	G_s	-	Specific gravity
h_0	-	Original height	w	-	Moisture content
h_f	-	Final height	PI	-	Plasticity index
δ_s	-	Collapsibility coefficient	h_z, h_{zs}	-	Soil sample thickness
Δe	-	Void ratio reduction during soil saturation	h_i	-	Initial soil sample thickness
eL	-	Void ratio before saturation	γ_d	-	Dry unit weight
i_c	-	Collapse potential	e_o	-	Original void ratio
m	-	Natural moisture content	e_i	-	Initial void ratio
S_r	-	Soil saturation ratio			
PL	-	Plastic limit			

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CHAPTER 1

INTRODUCTION

1.1 Background of study

Collapsible soil is a phenomenon where the soil structures are unstable and thus collapse and residual soil is a type of soil that yields from the weathering process of rock. The collapsibility of residual soil can be found in every country in the world. The main problem of residual soil is that it always relate to the effect of high rain fall rate and the effect of water to the soil.

According to Kepli (1994), Taha, et al. (1997) and Khairul (2002), Malaysia Tropika Climate namely experience humid year round having average temperature between 22 °C till 32 °C and annual rainfall torrent between 1778 mm to 3659 mm. This state cause occurrence of very high weathering rate on granite rock. Hence, residual soil formed in granite rock surface part.

This factor has because many incidents happened particularly in Malaysia, whether it is a natural slope or man-made slope. Many landslides occurred on residual

soil during heavy rain season. This incident could threaten human life and damage property. Although people know that it is dangerous to build something on the residual soil, but people still use is for development. This is because the addition of population and increase in standard of living and economic. Many construction work is carried out in residual soil area which found on highland area or hilly. Residential area, road, dam and recreation centre also involves at hilly area. Apart from that, because of residual soil is easy to get with lower cost, which is why residual soil is always selected as one of the building material.

Study of residual soil in Malaysia has long carried out. Among earlier researcher are Lee (1967), Chan & Chin (1972),Ting & Ooi (1976), Balasubramaniam, *et al.* (1985), Komoo (1985, 1989), Todo & Pauzi (1989), Tan & Ong (1993), Tan (1995), Taha, *et al.* (1997), Low, *et al.* (1997), Saravanan, *et al.* (1999), Ali (2000) dan Khairul (2002).

1.2 Problem statement

According to Brenner et al (1997) and Huat et al (2007), residual soil in Malaysia covering more then 80% of the country land area. The existence of this residual soil makes it difficult for engineer in Malaysia to choose the site that free from residual soil. Eventually site with residual soil is use for development.

Residual soils are defined as the product of insitu weathering of igneous, sedimentary and metamorphic rock (Blight, 1997). Ideally, there is no universally accepted definition of residual soils. Different researchers gave different definitions. For example, according to Fookes, (1990) residual soils are formed by the mechanical and chemical weathering of parent rocks at the present location. However, the common

phenomenon in all such definitions is that the residual soil is a material formed in situ by weathering of rocks and remained at the place where it was formed.

Because of these factors, many incidents relate to the collapse of soil has occurred in Malaysia and has kill many people and damage properties. For example the Highland Towers apartment building which collapsed on Dec 11, 1993, killing 48 people and at Bukit Antarabangsa which collapsed on Dec 6, 2008 that involve more than 2000 resident in that area (The star team, 2008).

The thesis focused on the effect of moisture content on collapsibility rate at Gambang residual soil. Gambang situated at about 25.5km from Kuantan Pahang. Gambang also are no exempt experience landslide. This is because, several cases has occurred at this place for example slope near to the Kolej Komuniti Paya Besar (KKPB). Below is the picture of soil collapse near the KKPB.

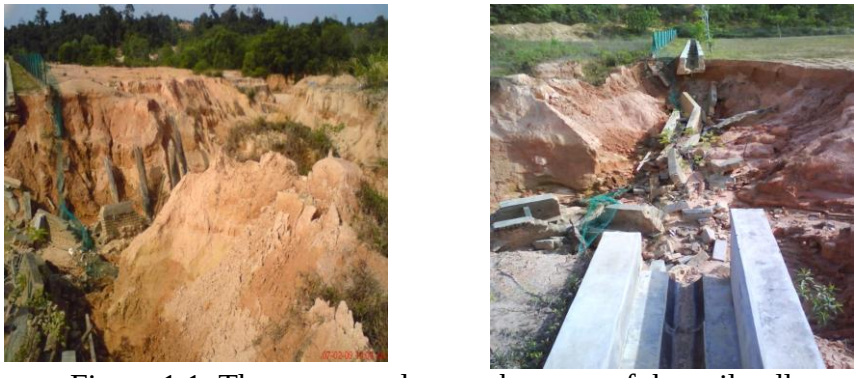

Figure 1.1: The property damage because of the soil collapse

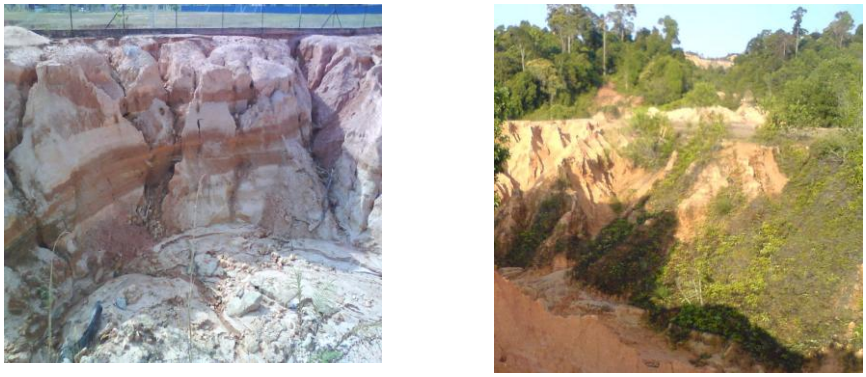

Figure 1.2: The effect of the soil collapse on the surrounding area

1.3 Objective

The main objective of this study is:

1. To determine the effect of moisture content on the residual soil
2. To determine the collapsibility rate of residual soil at Gambang.

1.4 Scope of study

The main purpose of this research is to determine the effect of moisture content on the residual soil and the collapsibility rate of residual soil at Gambang. Both objectives are determined via laboratory test. Two types of sample will be taken to succeed this objective. The first one is undisturbing sample and the second one is disturb sample.

Undisturbed sample will be used on single and double oedometer test. This test is carried out to determine the collapsibility rate of the soil sample from the calculation of this formula.

$$\text{Collapse Potential} = \frac{e_{unsoked} - e_{soked}}{1 - e_{unsoked}} \quad (1.1)$$

Where Δe represents the increase (for swelling condition) or decrease (for collapse condition) in void ratio (after 24 h) of the specimen on wetting under the desired pressure (20, 40, 80, 160, and 320 kPa) and unsoaked is the void ratio of the unsoaked specimen at that pressure. The term Δe assumes a positive sign when the sample swells and a negative sign when the sample collapses.

1.5 Expected result

From this research, the researchers expects that by adding more water to the residual soil the collapse potential will increase according to the amount of water is added. Researcher also expects that the value of collapse potential is more that 10%.

1.6 Thesis organization

This thesis composed of 5 chapters. Chapter 1 presents about general information regarding background of study, problem statement, objectives, scope of study and expected result. Chapter 2 provides the background of the study on different topics related to the research. This chapter contains the definition of the residual soil from the previous researchers, the more detail background of the study, material and method that can be used and a summary of the experiment that can be conduct in this study. Chapter 3 provides the method used in getting the result. This chapter also discusses the detail set up and procedures of using double oedometer test.

Chapter 4 present about the results obtained from the laboratory test and also calculation of collapse potential using theoretical formulae. The analysis of the result also will be doing in this chapter. Chapter 5 presents the summary and conclusions of major findings of this research and recommendation for future work on the topic related to the present study.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In Malaysia, residual granite and sedimentary rock soils occur extensively, covering more than 80% of the country's land area. The ground water table is generally low causing the soils to be mostly unsaturated except immediately after rain. These soils generally belong to the residual soil category that may exhibit collapse settlement upon wetting (B.K. Huat et, al. 2008).

During rainfall, the water will penetrate to the soil and fill up the void in the soil. Soil with high void ratio and has low shear strength will slide especially soil at the hill side, when soil at hill or slop slide or fell, it called slope failure, slope failure is one of the nature disaster that can give a big impact to the development and safety in some places.

The thesis focused on the collapsibility rate of Gambang residual soil. Throughout this chapter, the relevant journals and articles of collapsibility of soil and residual soil was reviewed. To understand the soil behavior at Gambang, a soil sample is taken to be analyzed. This includes analyzing the shear strength of soil and void ratio of the soil.

Gambang situated at about 25.5Km from Kuantan Pahang with latitude 3.716667 longitudes 103.1 and temperature 28°C. Gambang has been chosen as a case study because of it topography is hilly and it also has a history on landslide.

The literature review was also undertaken to study the collapsibility rate using double oedometer test. With the available information, the theoretical, conceptual and methodological background of the entire research was established in the literature review.

Figure 2.1: Location of Gambang from Kuantan (Travelsjournals.net, 2009)

2.2 Definition

Ideally, there is no universally accepted definition of residual soils. Different researchers gave different definitions. Table 2.1 below shows that the definitions that has been made by the previous researchers.

Table 2.1: Some definition of residual soil

Author	Definition
Fauziah Ahmad et, al. (2006)	Residual soil is a material formed in situ by weathering of rock and remained at a place where it was formed.
Macari E.J. and Hoyos L. (1996)	Residual soil is product of the intensive in-situ weathering of igneous, sedimentary and metamorphic rocks, and they include the group of iron rich materials usually described as lateritious or lateritic soil that are very common in tropical regions.
The Public Works Institute of Malaysia	Residual soil is a soil which has been formed in situ by decomposition of parent material and which has not been transported any significant distance.
Huat B.K et, al. (2008)	Residual soils is a soil that formed by the mechanical and chemical weathering of parent rocks at the present location.
Mohd Ahmadullah Farooqi, 2006	The tropical residual soils are formed in tropical areas, physically defined as the zone contained between 20^0 N (Tropic of Cancer) and 20^0 S (Tropic of Capricorn) of the equator, which includes Malaysia
Faisal Hj. Ali, 2005	Residual soils are soil that has been developed by in situ weathering of parent rock. In the tropic, heavy rains and high tempreture has lead to intensive chemical weathering leading to formation of tropical soil of several tens meter deep.

Based on all the definitions of residual soil listed in Table 2.1, authors have made a generalization to the definition of residual soil as a soil that was formed due to the weathering process of underlying rock and resided at the present location.

For collapsible soil definition, it is defined as soil that is susceptible to a large and sudden reduction in volume upon wetting. Collapsible soil deposits share two main features, they are loose, cemented deposits, and they are naturally quite dry (Day, 2000). Collapsible soil can withstand a large applied vertical stress with small amount of compression, but then showed much larger settlement upon wetting, with no increase in vertical stress (Bujang B.K. Huat et. al., 2008).

2.3 Background of study

In 20's century, it seem that the increasing demand and requirement for space and clearing for purposes of development which covered city, satellite city and larger highway. Consequently those areas considered unsuitable to development have in explored. Slope which is common topography shape on earth do not miss in development activities. The fact is human had fully utilized natural resource by found up-to-date methods to adapt development to appearance diversity landform. (M. Daniel, 2006).

Slope term discussed in this study referring to any land mass which form horizon in land surface. Hills, mountains river bank is an example of natural slope, it is form from the movement of glassier, weathering, erosion, sedimentation and deposition. Example of man made slope is fill slope, like filling and earth dam. Example of cut slope is cutting on the hillside to build a highway, railway, build drain excavation for foundation. (M. Daniel, 2006).

According to Z. M. Mansor, Z. Chik and M.R. Taha (2005), soil prone to collapse when large and sudden reduction in volume upon wetting. In their natural, dry state most residual soils form good foundation ground, retaining vertical slopes and are quite capable of bearing soil pressures up to 400 kN/m². The main contributor to slope failure is the force of gravity. When the driving forces (shear stress) overcome the resisting forces or shear strength on the slope, gravity is able to displace and move the slope forming materials (T. Periasamy, K. Osman Salleh, 2008). The movement of slope material or regolith may take a few millimeters to a few meters.

However, on exposure to wetting, they undergo a sometimes catastrophic loss of strength, perhaps with an associated settlement of up to 20% of the soil volume (Jon L. Darwell and Bruce Denness, 1976). Beside of wetting that cause slope failure, there are other factors that cause slope failure like high void ratio, soil exhibit significant strength and low compressibility at their natural (D.Harmdee, H.Ochai and N.Yasufuku, 2004). Many authors have written on the causal factors of slope

failures. The effect of collapsibility of soil results in lost of live, property, accommodation, and public amenities. Lot of land slide has occurred especially in Malaysia. At Dec 11, 1993 a tragedy at Highland Towers apartment building which collapsed has killed 48 people and now at 6 December 2008, a land slide has occurred at Bukit Antarabangsa. The incident make a lot of people lost their family members and properties. The occurrence of this entire land slide has open society's eyes of importance to understand landslide failure.

A study of slope failure has started in the early 19th century by a French engineer named Alexandre Collin he noted that the failure surfaces formed by landslides in clay along canal banks followed a curved form. In 1846 he published a memoir in which he proposed a statical method of analysis based on a curved surface and measured shear strength of the soils. Since that time various analyses have been proposed, resulting finally in the slip circle method developed by Swedish harbour engineers that forms the basis of techniques in current use.

General slope failure include falls, flow and slide. Most of the landslides occur are cause by a presence of water where rainfalls become a main factor (M. Daniel, 2005). The open structure that encourages strong root development also makes the soil susceptible to collapse upon the application of load and/or water. In Hong Kong for example, the study of movement of water in the soil because of a heave rain fall has been made to overcome the land slide from occur (J. J. Jiao and A. W. Malone, 2002).

Because of Malaysia experience a tropical climate and have a high rainfall distribution average, most of the collapsibility of residual soil is because of the reaction of water that is rain fall as a main factor other then erosion and weathering process.

Other then study the effect of water on the slope failure, the characteristic of the soil also taken to determine the condition of the soil using the appropriate test at the laboratory. Commonly residual soil is the most common soil that usually found in Malaysia and because of its certain characteristic that permeability and strength cause the influence of residual soil could not be dismissed.

2.4 Materials and Method

This section will discuss about the material and method that will be used in this study base on the literature review.

2.4.1 Material

From the entire journal that have collected and studied, material that had been used for the entire test that had been conducted by this people is soil that is undisturbed. For example in the journal entitle "Role of micro fabric in matrix suction of residual soils" written by Sudhakar M. Rao and K. Revanasiddappa. It stated at its method that the undisturbed sample was obtained from 2m deep test pits. Same with the other journal that I have collected for example journal written by Z. M. Mansor, Z and Chik, M.R. Taha, (2005). It stated that "the undisturbed soil specimen at natural moisture content loaded in the conventional oedometer" and journal written by Fauziah Ahmad, Ahmad Shukri Yahaya and Mohd Ahmadullah Farooqi, 2006. It stated in its journal that an undisturbed sample should be used to get more reliable result even though trimming of undisturbed samples is difficult because of gravel contents.

Undisturbed soil samples are those that are cut, removed, and packed with the least possible disturbance. They are samples in which the natural structures, void ratio, and moisture content are preserved as carefully as possible. Types of undisturbed samples are chunk samples, cut by hand with a shovel and knife, and cylinder samples, obtained by use of a cylindrical sampler or the CBR mold equipped with a sampling cutter. Expedient methods of obtaining cylinder samples are also used the method of sampling chosen depends upon the equipment available, the tests required, and the type of soil. All undisturbed samples must be handled with care.